

2

STAMP
FILE COPY

A RAND NOTE

The Effects of Defense and Security on Capital Formation in Africa: An Empirical Investigation

Daniel F. Kohler

September 1988

AD-A216 899

DTIC
ELECTE
JAN 19 1990
S D D

DISTRIBUTION STATEMENT A
Approved for public release
Distribution Unlimited

40 Years
1948-1988

RAND

9 0 01 18 0 16

The research described in this report was sponsored by the Office of the Under Secretary of Defense for Policy under Contract No. MDA903-83-C-0148.

The RAND Publication Series: The Report is the principal publication documenting and transmitting RAND's major research findings and final research results. The RAND Note reports other outputs of sponsored research for general distribution. Publications of The RAND Corporation do not necessarily reflect the opinions or policies of the sponsors of RAND research.

A RAND NOTE

N-2653-USDP

The Effects of Defense and Security on Capital
Formation in Africa: An Empirical Investigation

Daniel F. Kohler

September 1988



Prepared for
The Office of the Under Secretary of Defense
for Policy

Accession For	
NTIS CRA&I	<input checked="checked" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

40 Years
1948-1988

RAND

PREFACE

This Note is one in a series reporting on the findings of a RAND project on Defense and Development in Africa. This project is part of RAND's international economics program in the National Defense Research Institute, a Federally Funded Research and Development Center, and is funded by the Office of the Assistant Secretary of Defense (International Security Policy). The technical client for this project is the Africa Region, Office of the Assistant Secretary of the Defense for International Security Affairs, Department of Defense.

The research output from this project should be of particular interest to policymakers concerned with economic development and security policy in that region. Upon project completion and review, a summary report will be made publicly available. Copies of the database will also be made available to interested parties.

Other publications from the same project include:

- James Rosberg, Kwabena Gyimah-Brempong, and Francois Goreux, *Defense and Development in Africa: Annotated Bibliography*, N-2657-USDP.
- Patrick J. Murphy, *Defense and Development in Sub-Saharan Africa: Database and Codabook*, N-2651-USDP, 2 vols.
- Kwabena Gyimah-Brempong, *Defense and Development: A Review of the Statistical and Econometric Literature*, N-2650-USDP.
- Judith C. Fernandez, *Some Evidence on the Relation Between Military Rule and Economic Regime in Sub-Saharan Africa*, N-2652-USDP.
- Elliot Berg and Alexander Berg, *Security Expenditures in Senegal: An Analysis of National Data*, N-2655-USDP.
- Elliot Berg with the assistance of Jeremy Foltz, *The Nonmilitary Uses of Military Forces*, N-2656-USDP.
- Kwabena Gyimah-Brempong, *Patterns of Military Expenditure in Africa: 1965-1986*, N-2654-USDP.

SUMMARY

The military influences economic development in many, often contradictory, ways. On the negative side, the resource demands of the defense establishment compete with civilian demands. On the positive side, the military may increase security, which should lead to higher investment and growth. Finally the military may indirectly foster economic development because of its "modernization perspective" (Benoit, 1978) or because military officers are somehow better economic managers. It is of course also possible that those in the military are worse economic managers, and that their dirigistic tendencies retard, rather than foster, an economic environment where growth is possible.¹

This Note is an attempt to quantify the economic effects of the military's primary function, that of providing security. Specifically, it seeks to determine whether the positive effects on investment of increased security outweigh the resource costs in forgone investment of defense. An econometric model is constructed and applied to data from 27 Sub-Saharan African countries from 1971 through 1981. The results clearly support the hypothesis that a well equipped and well trained army can induce additional investment presumably through its security enhancing effects.

Although the topic of the research and the structure of the econometric model are perfectly general, the application is specific to Africa. This geographic concentration was chosen for a number of reasons. Despite considerable differences among countries, there is undeniably greater homogeneity among African countries than among developing countries from different regions. Most of the countries considered here are relatively young, having become independent only since World War II, their defense establishments are relatively small by world standards, and there is virtually no local arms production. This simplifies the econometrics somewhat because fewer variables have to be

¹See Fernandez and the literature reviews by Gyimah-Brempong and Rosberg et al. (1987) for a more thorough discussion of these issues.

controlled for and Keynesian multiperiod multiplier effects on local production and employment are considerably less important. They are disregarded here because their effects are unlikely to alter our conclusions.

Despite these similarities, there is considerable variation among African countries as well. About one-third of the countries considered here are ruled by military regimes. Some, for example those bordering on Libya or South Africa, face serious external threats, whereas others are relatively secure. This diversity makes it possible to identify some of the security effects of interest here.

Finally, Africa as a region has been less thoroughly analyzed than Latin America or the Middle East, for example. It is also a region where economic development concerns are most pressing. Given the poor economic performance of many African countries over the recent past it is legitimate to ask whether the increased militarization that may have taken place can in part be blamed for this.

The answer is clearly "no." We find that countries that are threatened and thus suffer from a low level of security have reduced gross fixed capital formation. However, countries that devote more resources to defense have higher gross fixed capital formation, presumably because the increased defense expenditures also increase security.

However,

Interestingly, the same is not true for the size of the armed forces. Large armies, especially when they are accompanied by low defense expenditures, have a negative effect on gross fixed capital formation. One can infer that large armies are not security enhancing and may indeed reduce security. *Subsaharan Africa, Foreign aid*

As part of the model the determinants of security expenditure and size of the armed forces were analyzed. It was found that countries allied with the Soviet Bloc tend to have much larger armies than would be justified by the threats they face. On the other hand, countries that have cooperation agreements or treaties with a western country have lower military expenditure than average but nevertheless have higher gross fixed capital formation.

Foreign aid

ACKNOWLEDGMENTS

A number of people have been of great assistance to me in the writing of this paper. Professor Robert West at Tufts University has made his data available and has also helped me understand and interpret the information contained in the files. Pat Murphy has constructed the workfiles and run most of the regressions, and Mary Anne Doyle has provided valuable research and administrative assistance. A number of my colleagues at RAND, in particular Frank Camm, Peter Reuter, Don Henry, and Ed Park have given generously of their time and discussed different aspects of the model with me. Professor Richard Porter at the University of Michigan provided a very thorough and insightful review of the entire paper. While each and every one of these people has contributed to this paper, none other than myself should be held responsible for any remaining errors.

CONTENTS

PREFACE	iii
SUMMARY	v
ACKNOWLEDGMENTS	vii
TABLES	xi
Section	
I. INTRODUCTION	1
II. DETERMINANTS OF DEFENSE EFFORT	5
Military Expenditure	6
Size of the Armed Forces	11
III. DETERMINANTS OF FIXED CAPITAL FORMATION	16
A Flexible Accelerator Model of Fixed Capital Formation	17
Determinants of Expected Growth	19
IV. ECONOMETRIC METHODS AND RESULTS	23
The Estimation Model	23
The Data	25
Estimation Procedure	27
Parameter Estimates	28
V. CONCLUSIONS	40
Appendix	
A. COEFFICIENT ESTIMATES	45
B. DERIVING MULTIPLIERS AND ELASTICITIES	49
BIBLIOGRAPHY	55

TABLES

2.1. Soviet-socialist countries in Africa	14
4.1. Data coverage	26
4.2. Parameters of the expected growth equation	30
4.3. Multipliers for transformed variables	32
4.4. Multipliers for variables measured in natural units	35
4.5. Elasticities for variables measured in natural units	37
A.1. Coefficient estimates for different variants of the estimation model	48
B.1. Multiplier formulas for transformed variables	49
B.2. Multiplier formulas for variables in natural units	53
B.3. Sample means for variables used in the model	54

I. INTRODUCTION

The effect of the military, often simply measured by defense spending, on economic development has been a topic of much heated debate ever since Benoit first postulated a positive relationship between the two variables.¹ Unfortunately Benoit's empirical work was flawed, as numerous critics have pointed out, and other researchers, using different and not always better methodologies, have found contrary results.² The only unambiguous conclusion coming out of this set of analyses is that the results depend heavily on the countries and time periods chosen.

This study is an attempt to investigate the relationship among defense related variables, such as military expenditure, and economic development and growth in Sub-Saharan Africa. It is based on the most recent data available and concentrates on those aspects of particular importance to economists concerned about economic growth. It is based on a simple accelerator model of investment and thus on neoclassical economic growth theories.

As a proxy for economic growth we use gross fixed capital formation. There are several reasons for this choice: First, economic growth cannot be observed directly and contemporaneously. It is only over time that we are able to measure increases in gross national product (GNP) or gross domestic product (GDP). Second, economic growth also depends on a large number of factors that are not under the control of policymakers, such as weather, international developments, etc. By choosing gross fixed capital formation as a proxy for economic growth, we concentrate on one necessary, if not sufficient, condition for development, that is furthermore likely to be influenced by security considerations. This link is the major focus of this Note.

¹Benoit (1973, 1978).

²For a discussion of this literature see Gyimah-Brempong.

This Note also attempts to address some of the oversights in the current literature on this topic. For example, most studies on the relationship between military and economic development lack a coherent explanation of the mechanisms by which militarism influences economic growth. Benoit had postulated a number of linkages, ranging from the "modernization perspective of the military" to "spillover effects of military R&D," whereas his critics have usually tended to stress the military's competition for resources that could be used more productively in development related activities. Very few researchers have ever explicitly considered that the military's primary function, to provide security from external and internal threats, could have economically beneficial influences.

There is also more than a little confusion on how to measure the military's influence. Researchers tend to use military expenditure, either normalized by GDP or in real per capita terms, as an indicator variable. Less frequently, the ratio of the armed forces to the general population is used. Although both measures have fairly clear definitions, they can hardly be viewed as measures of "influence," which might explain why and how the "modernization perspective" of the military takes hold.

This is doubly true in Africa, where importance in numbers or equipment has never been a prerequisite for the military to wield influence. In the young states of Sub-Saharan Africa, even small and modestly financed armies have repeatedly proven their clout. Mobutu seized power in the Belgian Congo (now Zaire) with 200 men, President Soglo of Dahomey (Benin after 1975) was deposed by 60 paratroopers.³ Today about half of the countries in Africa are governed, in one form or another, by their armies.⁴ This most obvious manifestation of military influence persists despite the fact that in terms of resources devoted to defense, most African countries, as well as the region as a whole, are considerably below the averages for the developed or developing world.

³Baynham (1976).

⁴Ibid.

There are other ways in which Africa presents a special case. It would be almost ludicrous to talk about spillover R&D effects from military spending in Sub-Saharan Africa. We cannot even argue that military spending in this part of the world greatly stimulates the economy, since virtually all equipment, from ammunition to arms to uniforms, is imported. The only portion that is spent domestically is that which covers salaries, food, and other personnel compensations.

If the military in Africa has any positive effects on economic development, they must come from its traditional role as a security force. Security influences development through its effect on investor confidence. Private domestic investors, as well as foreign investors (or foreign bankers financing government investments), will be more willing to invest in countries that seem relatively secure, all other things held equal.

Security is an elusive concept; it cannot be observed or measured in the way other variables can be measured. Even worse, from the econometrician's point of view, what matters in investment decisions is not so much a somehow objective assessment of the security situation as the investor's perception of that situation. We can hypothesize, though, that in general the strength of the defense forces should increase security, objectively as well as in the investors' perception, and the presence of external and internal threats should reduce it.

Rational governments will respond to threats by increasing the resources devoted to defense. This is one variable that can be measured, albeit imprecisely.⁵ However it cannot be considered exogenous, i.e., determined independently of other variables in our model. The first order of business in attempting to explain the relationship between defense and economic development must therefore be an investigation of the determinants of the military variables, especially the size of the armed forces and military expenditures.

⁵Unfortunately very few countries make a proper accounting of their defense expenditures, and we have to resort to various estimates.

The next section (Sec. II) presents a simple linear regression model that explains a country's defense effort. Only the two major components of defense effort--military expenditure and the size of the armed forces--are considered here. Relatively few variables can account for much of the variation in MILEX (Military Expenditures/Gross Domestic Product) and FORCE (Size of the Armed Forces/Population) between countries and over time. The resulting estimates provide some insights into which variables tend to be associated with larger defense spending in Africa, and which kinds of African countries tend to have large armies, relative to the size of their populations.

Section III develops a model of investment behavior, more accurately, of fixed capital formation. The model is based on standard economic theory of aggregate production and investment and focuses in particular on those variables that must have an influence on the investors' perceptions about security. Since security cannot be measured, it is treated as a latent variable, and those observable variables that must have an influence on security, i.e., MILEX, FORCE, as well as indicators of security threats, are used in the investment equation.

The model developed in Secs. II and III gives rise to a number of econometric problems that are discussed in Sec. IV. Section V discusses some of the idiosyncrasies introduced by the availability of data and presents the empirical results. Conclusions and implications for U.S. policy in the region follow in Sec. V.

II. DETERMINANTS OF DEFENSE EFFORT

The number of studies attempting to explain the level of defense effort undertaken is considerably smaller than the number of studies taking military expenditure and the size of the army as given.¹ We are unaware of any effort to explain size of the armed forces and defense spending jointly in a simultaneous system, even though they are certainly related and are the outcome of a joint decision by the respective governments. This section will present a model of resource allocation to defense as a function of a series of independent variables, chiefly among them political systems variables (socialist regime, military regime), indicators of security threats, and alliance to global power blocs.

For reasons that will become clear below, we will normalize military expenditure by GDP, calling the measure MILEX, and the size of the armed forces by population (FORCE). There is a fundamental asymmetry in the definition of these two measures, even though both are ratios and thus pure numbers. MILEX is a ratio of numbers originally measured in currency units, whereas FORCE is based on counts of people. Had it been possible to obtain information on the military wage, or had military expenditure data been available in more disaggregated form, one could have devised a common normalization. More important, it would have been possible to break out personnel compensation from military expenditure, so that the remainder would have measured the nonpersonnel component of the defense budget.

As it stands, MILEX and FORCE are related on a trivial level as well as by the joint decision hypothesis advanced in this Note. MILEX, as defined here, is identical to the sum of two ratios, the ratio of expenditure on equipment and other military capital to GDP, and the ratio of the military wage to real per capita GDP multiplied by FORCE. The coefficient of FORCE in the MILEX equation will thus be the sum of

¹See Gyimah-Brempong.

the measure to which increasing troop strength leads to increased expenditure on equipment and the ratio of the military wage to real per capita GDP. Because no data on the military wage were available, these two effects could not be identified separately. The other coefficients remain unaffected, since FORCE acts as a control variable in MILEX.

This model is a subpart of the overall model discussed in this Note. It was estimated jointly with the investment model presented in the next section. The estimates from the overall model revealed that although the measures of defense effort influenced fixed capital formation, there was no significant influence detectable in the opposite direction. In a simultaneous system, the estimated coefficient on fixed capital formation as an explanatory variable in the defense effort equations was not significantly different from zero.

This section presents the main features of the model and gives some indications on the direction and magnitude of the estimated coefficients. The detailed results with all the associated statistics are presented in Sec. V.

MILITARY EXPENDITURE

Measuring Military Expenditure

Data on military expenditure is notoriously unreliable. Few governments willingly publish how much they spend on defense. Often the budget of the department of defense contains only a portion of defense related expenditures, other portions being distributed among various other departments (infrastructure, finance, etc.). Often the office of the president directly pays for a substantial part of the security expenditures, and government-wide financing banks are responsible for repayment of loans used for weapons imports. Ball (1984) has attempted to reconcile some of the statistics and to correct for the variance in accounting practices; however, her data are available only for a small number of African countries for selected years.

In developing countries, particularly in Africa, problems are compounded by the need to convert and deflate defense expenditure estimates from different countries. Reliable price indexes exist only for very few countries in Sub-Saharan Africa, and official exchange

rates are chronically overvalued.² West (1986) has developed comparable estimates of defense expenditure based on purchasing power parity indexes. These measures represent a substantial improvement to exchange rate based estimates; however, they are still quite far from ideal.

The problems of deflation and exchange rate conversion can be avoided when military expenditure is normalized by dividing it by GDP.³ The ratio of military expenditure to gross domestic product represents a measure of the defense effort that a country is undertaking. Both military expenditure and GDP can be taken in current (undeflated) local currency units. Any deflator or exchange rate would affect both numerator and denominator in the same way, and would thus cancel out, provided the same deflator is used throughout.⁴

This study uses the ratio of military expenditure to GDP (called MILEX hereafter) as the relevant measure of defense effort. In addition to avoiding the sundry problems associated with deflation and currency conversion, MILEX as a measure of defense effort also obviates the need to correct for the size of the economy when analyzing defense expenditures. Only if one expects nonlinearities or economies of scale in the use of military expenditure for security production, or if the income elasticity of demand for security is significantly different from one, would GDP or GDP per capita still have to be considered separately. If this were the case, countries with a larger GDP would, *ceteris paribus*, spend *proportionately* more or less on defense than countries with a smaller GDP. Several specifications were tried and there is no evidence that, once the other explanatory variables are included, GDP has an independent influence on defense effort as measured by the ratio of military expenditure to GDP.

²See Fernandez.

³Alternatively, one might consider using GNP in the denominator. It differs from GDP by the amount of net factor payments abroad.

⁴Reliable estimates of GDP deflators are not available for all African countries and we are unaware of any country where separate deflators for individual GDP components have been developed.

Explaining MILEX

The most important determinant of military expenditure is, of course, the size of a country's armed forces. Given the definition of MILEX, which includes expenditures on military personnel, the two variables are linked by definition through the military wage. Furthermore, the model presented here also postulates that decisionmakers determine military expenditure and the size of the armed forces simultaneously, taking into account substitutabilities and complementarities. In this manner variables that influence the size of the armed forces (discussed below) have an indirect influence on military expenditure and vice versa.

A rational government will respond to security threats by increasing its defense effort. Accordingly, one would expect that threatened countries spend, *ceteris paribus*, a larger proportion of their GDP on defense. The problem here is how to measure the threat that a country faces. Security threats can have a number of different origins, internal (e.g., guerilla activity) or external (e.g., aggressive neighbors). In any case it is unlikely that a single measure could be devised that captured all the dimensions of security threats.

In the practical application three different variables, each measuring a different component of security threat, were found to be significant predictors of defense expenditure: (i) a dummy variable indicating serious guerilla activity in the country (GWDUMMY), (ii) a dummy variable equal to one for countries bordering either on South Africa or on Lybia (THRT), and (iii) the ratio of the weighted sum of MILEX in neighboring countries to own MILEX (BORTHRT). As weights for the summation, the proportion of shared border was chosen, and the variable was lagged by one year to avoid simultaneity problems.

The first of these variables is a crude indicator of the internal security situation. It was taken from the Cross-National Time-Series Data Archive compiled by Arthur Banks, The Center for Social Analysis, State University of New York (Binghamton).⁵ This source actually

⁵Banks (1979).

carries a count of the number of guerilla incidents; however, it was found to be not very reliable, and a simple indicator equal to one if there was any guexilla activity at all performed better in the estimation.

The second threat variable (bordering on Lybia or South Africa) was chosen because these two countries have demonstrated not only their ability, but also their willingness, to invade their neighbors. In addition, they are not part of the group of countries studied here and security threats emanating from these countries can thus, for the purpose of this model, be considered as exogenous.

The third threat variable is military expenditure in neighboring countries relative to own military expenditure. Even though it is unlikely that any one African country would be in a position to carry out a sustained operation in a neighboring country, this variable nevertheless can serve as an indicator of regional tensions. Attempts at distinguishing "friendly" and "unfriendly" neighbors quickly bogged down because of the high degree of instability in international relations among African countries. Who, for example, would have considered Mali and Burkina Faso "unfriendly" neighbors before the Christmas war of 1985?

An active, ongoing war does, of course, also lead to increases in military expenditures. Not surprisingly, an indicator variable (WAR), equal to one if the country is actively engaged in armed conflict with one of its neighbors, has a significant influence on explaining military expenditure.

A hypothesis often advanced in the literature is that superpower competition pushes the developing countries into an arms race. The superpowers, or other patron states, influence their clients to spend more on defense than they otherwise would. To test a somewhat more differentiated form of that hypothesis, two variables were introduced. COOPWEST is a dummy variable equal to one if the country has an active cooperation agreement or treaty with one or several western developed countries; COOPEAST is a dummy variable equal to one if the country has an active cooperation agreement or treaty with the Soviet Union or another Eastern Bloc state. The data for these agreements were taken

from publications by the International Institute for Strategic Studies in London.⁶

These variables have opposite effects on military expenditure. COOPEAST has a positive sign,⁷ and COOPWEST has a negative sign. This implies that Soviet client states in Africa spend more on the military than neutral states in the same region, and Western client states significantly less. In other words, a cooperation agreement with the West leads to significant reductions on military expenditure, whereas a cooperation agreement with the East leads to increases.

An alternative way of explaining this difference is based on the different ways in which the Eastern Bloc and the West provide security assistance. The West tends to assist African countries through donated equipment and training. In addition, some western countries, such as France, station small contingents of their own security forces in the region. The Soviet Union and its allies tend to assist African countries by sending advisors and instructing them on how to build up the armed forces. Allegiance to the Soviet Bloc tends to bring with it a militarization of several aspects of African society, resulting in substantial needs for armaments. However, the Eastern Bloc has traditionally been very stingy with donated equipment, and African governments that want to acquire Soviet equipment usually wind up paying cash, an expense that should be reflected in the defense budgets of these countries.

Note that these effects are after correction for security threats, active wars, and guerilla warfare. It is incorrect to speculate that countries with active cooperation agreements with the Soviet Bloc were simply more threatened and had therefore a higher need for defense expenditure. The results also clearly debunk the contention that military cooperation treaties with the West lead to higher military expenditure in Africa. The opposite is true--military cooperation treaties with the West act as a substitute for military expenditure,

⁶IISS, *The Military Balance*, various issues.

⁷However, the coefficient estimates are not significantly different from zero in most specifications.

whereas cooperation with the East is a complement and leads to increased defense spending.

Finally an indicator variable equal to one if the country was effectively governed by the military (MIL) was included. It was taken from the Cross-National Time-Series Data Archive.⁸ Unlike all the other variables discussed in this section, MIL had no significant effect on military expenditure. It is not true that military regimes in Africa spend more on defense than civilian ones.

SIZE OF THE ARMED FORCES

Measuring the Size of the Armed Forces

Unlike NILEX, measuring the size of the armed forces poses no problems of currency conversion or deflation. However, all the other problems, particularly those associated with the secretiveness of the different states, are still present. It is also by no means clear what units ought to be counted as part of the "armed forces."

For example, should units of a border police force, armed only with light handguns, be considered part of the "armed forces"? How about the police force, or the "gendarmerie"?⁹ How about the forest service that receives military training in some African countries and is armed similarly to the border police? How about the presidential guard?

The data for armed forces used here come from the U.S. Arms Control and Disarmament Agency (ACDA).¹⁰ ACDA's definition includes "...active-duty military personnel, including paramilitary forces if those forces resemble regular units in their organization, equipment, training, or mission. Reserve forces are not included." Also excluded are uniformed forces performing primarily noncombatant services (e.g., construction).

⁸Banks (1979).

⁹The gendarmerie is an internal security force under the control of the ministry of defense and is common in countries with a French-type security organization.

¹⁰U.S. Arms Control and Disarmament Agency, *World Military Expenditures and Arms Transfers*, various years.

Although one might take issue with certain aspects of this definition, it offers at least the advantage of consistency. ACDA data are highly consistent across countries and over time. The same individuals have been responsible for compiling the series for the last ten years. ACDA also makes an effort to correct its data when new information becomes available and to update its earlier estimates. Unfortunately, other institutions that collect military information, such as IISS, are often unable to do this.

The ACDA estimate of the size of the armed forces was divided by the World Bank's estimate of the total population. For a few countries no World Bank estimate was available, in which case the figure given by the International Monetary Fund (IMF) was used.¹¹ This normalized variable (called FORCE from here on) is a better indicator of a country's defense effort than simply the size of the armed forces. Countries with a larger population to protect will, *ceteris paribus*, have larger armies exactly as countries with a larger GDP will devote more resources to defense. Both normalizations employed here--dividing military expenditure by GDP and armed forces by population--are fairly standard in the literature.

Explaining FORCE

As pointed out above, the model presented here determines MILEX and FORCE simultaneously. As expected, the coefficient of MILEX in the FORCE equation is positive and significant. This implies that an exogenous increase in MILEX will also induce an increase in FORCE. For example, if a country decides to improve its security position by acquiring some new weapons, it may also have to increase the size of the armed forces to man the new equipment.

Besides MILEX only two other variables were found to have a significant influence on FORCE: the proportion of the population

¹¹This practice of using the World Bank estimates first and complementing them with IMF estimates when no World Bank data were available was followed throughout for all variables taken from the World Bank.

enrolled in secondary school (SCHOOL) and whether the country was considered a member of the Soviet-Socialist Bloc (SOVSOC). MIL (the variable indicating military government) was also included but had no significant effect. It was nevertheless retained in the specification because its coefficient was significant at the first stage of the estimation (see below) and because it is a variable to which some researchers attach great importance.

Data on secondary school enrollment were taken from the State University of New York (SUNY) (Binghamton) data archive (Banks, 1979). It is based on data from the U.N. Statistical Yearbook, which defines secondary education as "...based upon at least four years of previous instruction at the first level, and providing general or specialized instruction."

The effect of SCHOOL on FORCE was found to be positive and significant. In other words, nations with a higher proportion of their population in secondary school also have a larger proportion of their population in the armed forces. This could be explained by a cohort effect: These countries have a larger proportion of their population in the age group that covers secondary education and armed service. Other possible explanations include:

- (i) Countries with higher secondary school enrollment ratios tend to be more urbanized,¹²
- (ii) Countries with high secondary school enrollments face larger internal security threats, and
- (iii) Armed forces absorb skilled manpower so that countries with higher numbers of secondary school graduates have a larger pool of potential recruits.

Finally it is not clear from the documentation whether members of the armed forces who are undergoing training are considered to be "enrolled in secondary education." Vocational training is not supposed

¹²Data on urbanization, though available from the World Bank, were found to be very spotty and provided much poorer coverage than school enrollment ratios.

to be included in the definition of secondary education as reported in the Cross-National Time-Series Data Archive, but the treatment of military education is not explicitly spelled out. If military training was considered secondary education, the positive coefficient would in part be simply due to double counting.

The strongest effect on FORCE, besides MILEX, comes from the dummy variable indicating whether the country has to be considered a member of the Soviet-Socialist Bloc. This variable was developed by RAND, based on cursory observation of a country's social organization, its foreign policy orientation, and the number and function of Soviet advisors.

Table 2.1 lists the countries included in this group.

One might suspect that the strong effect that SOVSOC has on FORCE was dominated by data from Angola and Mozambique. This is not the case. In the estimation, Angola and Mozambique drop out of the sample,

Table 2.1
SOVIET-SOCIALIST COUNTRIES IN AFRICA

Country	Years*
Benin	1970-1985
Congo (Brazzaville)	1970-1985
Guinea-Bissau	1970-1985
Somalia	1970-1977
Ethiopia	1978-1985
Guinea	1970-1978
Mozambique	1975-1985
Angola	1975-1985

*The data used here cover the years 1970 to 1985.

primarily because they lack data on some other crucial variables (e.g., fixed capital formation). The strong effect of SOVSOC on FORCE is thus present even without considering Angola and Mozambique.

Also note that the threats a country faces are included in the MILEX equation and are thus indirectly included in the FORCE equation as well. The strong influence of SOVSOC on FORCE is thus in addition to the effects of security threats and guerilla activity. In other words, two countries with the same population and equally threatened will have different size armies if one is a member of the Soviet-Socialist Bloc and one is not. The results presented in Sec. V indicate that adherence to the Soviet-Socialist Bloc increases FORCE by about 50 percent (1.2 percentage points).

The formal estimating equations will be presented in Sec. IV, where the econometric problems of estimation technique will also be discussed. The actual parameter estimates will be presented in Sec. V, together with the results from the investment equation. The specification of the investment equation, and the integration of security variables into that equation, will be the topic of the next section.

III. DETERMINANTS OF FIXED CAPITAL FORMATION

The accumulation of capital, both human and physical, is one of the prerequisites of economic growth. By investing in capital, investors forgo current consumption in favor of higher output in the future. Developing countries are thus interested in increasing investment in their economies, either directly, through government investments, or indirectly, by inducing their citizens and foreign investors to invest.

The model of investment presented here is based on the flexible accelerator model that is generally accepted in neoclassical economics. It is consistent with a number of aggregate production models, including the Cobb-Douglas production function. The model does not place much emphasis on the linkages between investment and aggregate output (GDP); it takes the economic theory in this area as given. Instead the focus is placed on how the security related variables, discussed in the previous section, interact with investment.

Besides its indirect effect on investment, through security, the military can directly contribute to capital formation in two ways: By training individuals, and providing them with management and vocational skills, the armed forces contribute to the formation of human capital. Through civic action, whereby military units undertake projects that result in capital useful to the civilian population (e.g., road construction), the military can contribute to the physical capital stock.¹

Neither of these contributions to capital formation are considered here. Measurement problems have made it impossible to include human capital in this model, and civic action is the focus of another Note in this series (Berg).

¹This is the traditional definition of "civic action." More recently this term has been associated with anti-insurgency activities by the armed forces, a function not considered here.

A FLEXIBLE ACCELERATOR MODEL OF FIXED CAPITAL FORMATION

The desired capital stock depends on expected output and the user cost of capital in the following way:

$$K^d = (\alpha/UC)Y^e$$

where K^d denotes the desired capital stock, Y^e is expected output, UC is the user cost of capital normalized by an output price index, and α is the share of capital in output.

Net investment is proportional to the difference between the desired capital stock and the actual capital stock. Specifically:

$$I_t^n = \lambda(K_{t+1}^d - K_t)$$

and gross investment is accordingly:

$$I_t = \lambda(K_{t+1}^d + (\delta - \lambda)K_t)$$

or

$$I_t = \lambda(\alpha/UC)Y_{t+1}^e + (\delta - \lambda)K_t$$

Unfortunately, neither K^d nor Y^e can be observed. Traditionally, researchers have constructed an estimate of Y^e , based on a distributed lag sum of past observed output (Clark, 1979). This approach is not well suited to developing economies, not least of all because we lack long time series.

For the model employed here we propose an alternative representation of expected future output. Without loss of generality, one can state:

$$Y_{t+1}^e = (1 + g_t^e)Y_t$$

In other words, expected output in period $t + 1$ is equal to current

output multiplied by one plus the expected growth rate. Substituting this expression into the equation for gross investment results in:

$$I_t = \lambda(\alpha/UC)(1 + g_t^e)Y_t + (\delta - \lambda)K_t$$

Dividing through by Y_t and multiplying by UC gives the final form of the investment equation:

$$I_t^* = \lambda\alpha(1 + g_t^e) + (\delta - \lambda)K_t^*$$

where the asterisks denote variables normalized by GDP and multiplied by the user cost of capital.

The expected growth rate is a function of a number of variables that vary between countries, such as the structure of the economy, foreign aid, and security, as well as a number of variables that are constant across all African countries. It is convenient, therefore, to break up the expected growth rate into two parts, i.e.,

$$g^e = g^a + g(X)$$

where g^a is the (common) average expected growth rate, and $g(X) = \sum_i \gamma_i X_i$ represents country- and time-specific effects. The explanatory variables X are standardized by subtracting out their respective means.

With this structure, and given an independent estimate of g^e , the investment equation can be identified. Suppressing the time subscripts, it can now be written as:

$$I^* = C_0 + C_1 X_1 + C_2 X_2 \dots C_L K^*$$

$$\begin{aligned} \text{where } C_0 &= \lambda\alpha(1 + g^a) \\ C_i &= \lambda\alpha\gamma_i \quad \text{for } i = 1, 2, \dots \\ C_L &= (\delta - \lambda) \end{aligned}$$

Identification proceeds as follows: Given the assumed value of the depreciation rate δ , an estimate of λ can be computed from C_L . Together with the independent estimate of g^a , this estimate of λ can be used to obtain an estimate of α from C_0 . Given the estimates of λ and α , the coefficients of the $g(X)$ function, the γ_i , can be computed from the C_i coefficients. The following section will discuss the explanatory variables X used in the estimation of the model.

DETERMINANTS OF EXPECTED GROWTH

Two variables that characterize the structure of the economy were included in the growth equation. They are the ratio of exports to GDP (EXPORTS) and the share of the mining sector output in GDP (MINLAG).² To avoid simultaneity problems the values for these variables were lagged by one period.

Both EXPORTS and MINLAG have a positive influence on expected growth rates. African economies that are more export-oriented, and those that have an important mining sector, appear to have higher expected growth rates. This coincides with (a priori) expectations.

All African economies are heavily dependent on agriculture. One would therefore expect that rainfall would have an influence on economic growth. If year t had good rainfall, GDP_t will be higher than normal. This implies that the expected growth rate from year t to $t + 1$ will be lower, i.e., rainfall has a positive effect on actual output in the current year, and thus a negative effect on growth expected between the current and the next year.³ Indeed, the rainfall variable that was chosen, total rainfall as a deviation from average rainfall (RAIN), does have the expected negative sign; however, it is not statistically significant.

²Note that petroleum production is included under "mining" and that the time period covered includes the periods of rapid petroleum price increases.

³However, a contrary effect is possible: High GDP in this period makes more resources available for investment, leading to a high growth rate.

For much of their investment, African countries depend on external financing. A country's international credit worthiness, or lack thereof, can be a serious constraint to investment and growth. The problem is how to measure credit worthiness. Most African countries borrow from a variety of sources, sometimes at commercial terms and sometimes at subsidized terms. The average interest spread they pay rarely reflects their overall credit standing. A better indicator of creditworthiness is determined as a country's ability to obtain loans from private sources, or nearly complete dependence on subsidized financing from bilateral or multilateral aid donors. In other words, the proportion of private unsecured commercial loans in overall borrowing can be taken as an indication of a country's creditworthiness. This variable (WORTH) does have a positive effect on expected growth and is statistically significant.

Foreign aid transfers resources to the recipient country. One would expect, therefore, that increases in aid are associated with increases in expected growth rates. At the same time, however, significant amounts of foreign aid go to the most needy countries, those that have little resources to invest. This leads to a negative correlation between growth and foreign aid.⁴ Indeed, the variable AID, defined as the ratio of foreign aid to GDP, has a negative sign; however, it is statistically not significant.

The determinants of security that influence expected growth rates consist of MILEX, FORCE, GWDUMMY, THRT, and BORTHRT. The last three have a negative effect on expected growth. If larger military expenditures and larger armies are indeed security-enhancing, these two variables should have a positive effect on expected growth. This is indeed the case for MILEX. However, FORCE has a negative effect on expected growth rates. The conclusion is that small armies well equipped and well trained are beneficial to economic growth expectations, presumably because they increase security. Large armies, however, especially when they lack the necessary resources, are not

⁴Also note that AID includes food aid for which one would expect effects similar to those for RAINFALL discussed above.

necessarily security-enhancing and have a negative effect on growth expectations.

This finding is not as counterintuitive as it might seem at first. Consider security being reduced by security threats and increased by defense. Defense is produced with manpower (labor) and equipment, training, etc. (physical and human capital). Despite the fact that data on MILEX include expenditures on manpower, autonomous increases in MILEX can, *ceteris paribus*, be viewed as increases in capital inputs, whereas autonomous increases in manpower increase labor inputs. For most African countries, the capital-to-labor ratio in the defense production function is very small, and the marginal product of labor in defense production is also very small, possibly even zero. Adding more soldiers to an already underequipped army adds little to defense capabilities, and it is not unlikely that these small additions are more than offset by the negative direct effects that additional troops have on security perceptions.

That soldiers without equipment, training, and especially without pay are a security risk has been observed repeatedly all throughout Africa. In many African countries soldiers have to grow their own food, which tends to put them in conflict with established farmers, or they have to "live off the land" in other ways. In some areas of Zaire it is not uncommon for soldiers to set up roadblocks to collect tribute payments from the civilian traffic, especially if, as often happens, the payroll did not reach the troops. Elsewhere soldiers have been known to collect protection payments from merchants to engage in less obvious forms of graft and corruption. Such situations are hardly designed to inspire investors with confidence and to make them feel secure enough to risk investing in fixed capital.

Countries that have cooperation agreements and treaties with major sponsors usually also cooperate with the same sponsors on economic matters and receive economic assistance. For this reason, COOPEAST and COOPWEST were included in the gross fixed capital formation equation as well. COOPWEST was found to have a positive effect, whereas COOPEAST had a negative, albeit statistically insignificant effect. Furthermore, these direct effects on gross fixed capital formation were found to be

strong enough to offset the indirect effects these variables had through the MILEX equation.¹ The same holds true for the variable WAR, which was found to have a negative, albeit statistically insignificant, direct effect on gross fixed capital formation.

Finally the actual growth rate experienced in the previous period was included. As expected it had a positive and statistically significant effect on expected growth rates. This variable (GROWTH) has primarily the role of accounting for unobserved variations among different countries that persist over time.

¹Recall that COOPWEST had a negative effect on MILEX and COOPEAST had a positive one. If COOPEAST and COOPWEST were not included in the investment equation, one would have to conclude that they have (indirectly) the same effects on gross fixed capital formation. However, the direct effects that these variables have on investment offset their indirect effects.

IV. ECONOMETRIC METHODS AND RESULTS

THE ESTIMATION MODEL

The model presented in the preceding sections can be estimated as a system of three simultaneous equations. Representing coefficients to be estimated by β_{ij} , where i denotes the equation and j the regressor, the system can be summarized as follows:

$$\begin{aligned} \text{FORCE} = & \beta_{10} + \beta_{11} \text{MILEX} + \beta_{12} \text{MIL} + \beta_{13} \text{SCHOOL} \\ & + \beta_{14} \text{SOVSOC} \end{aligned} \quad (1)$$

$$\begin{aligned} \text{MILEX} = & \beta_{20} + \beta_{21} \text{FORCE} + \beta_{22} \text{MIL} + \beta_{23} \text{WAR} \\ & + \beta_{24} \text{GWDUNNY} + \beta_{25} \text{THRT} + \beta_{26} \text{BORTHRT} \\ & + \beta_{27} \text{COOPEAST} + \beta_{28} \text{COOPWEST} \end{aligned} \quad (2)$$

$$\begin{aligned} \text{INVSTUC} = & \beta_{30} + \beta_{31} \text{MILEX} + \beta_{32} \text{FORCE} + \beta_{33} \text{MIL} \\ & + \beta_{34} \text{WAR} + \beta_{35} \text{GWDUNNY} + \beta_{36} \text{THRT} \\ & + \beta_{37} \text{BORTHRT} + \beta_{38} \text{COOPEAST} + \beta_{39} \text{COOPWEST} \\ & + \beta_{310} \text{GROWTH} + \beta_{311} \text{EXPORTS} + \beta_{312} \text{WORTH} \\ & + \beta_{313} \text{AID} + \beta_{314} \text{RAINFALL} + \beta_{315} \text{MINLAG} \\ & + \beta_{316} \text{KAPSHRUC} \end{aligned} \quad (3)$$

where the variables are defined as follows:

- FORCE = ratio of armed forces to total population
- MILEX = ratio of military expenditures to GDP
- INVSTUC = ratio of gross fixed capital formation to GDP, multiplied by user cost of capital
- MIL = dummy variable equal to one if country is effectively governed by the military
- SCHOOL = proportion of total population enrolled in secondary education
- SOVSOC = dummy variable for Soviet Socialist regimes (see Table 2.1)

WAR	= dummy variable equal to one if country is engaged in a war
GWDUMMY	= dummy variable equal to one if there is significant guerilla activity
THRT	= dummy variable equal to one if country borders on Lybia or South Africa
BORTHRT	= weighted sum of neighboring countries' military expenditure to own military expenditure, lagged by one period. (Summation weights: proportion of shared border; currency conversion at purchasing power parities. See Murphy for details.)
COOPEAST	= dummy variable equal to one if the country has an active friendship accord or treaty with the Soviet Bloc
COOPWEST	= dummy variable equal to one if the country has an active friendship accord or treaty with a Western power
GROWTH	= GDP growth rate, lagged by one period
EXPORTS	= ratio of exports to GDP
WORTH	= proportion of nonconcessionary bank financing in total borrowing
AID	= ratio of official development assistance to GDP
RAINFALL	= annual rainfall (deviation from 20-year average)
MINLAG	= proportion of GDP generated in the mining sector, lagged by one period
KAPSHRUC	= ratio of fixed capital stock to GDP, multiplied by user cost of capital

Strictly speaking the system is not fully simultaneous, but block recursive. The two equations of defense effort, FORCE and MILEX, are independent of the investment equations and could be estimated separately as a system of two simultaneous equations. The parameter estimates of the two-equation model would have been consistent.¹ Estimating these jointly with the investment equation by a systems method, such as 3 Stage Least Squares (3SLS), improves the efficiency of the parameter estimates.

¹This is the justification for discussing the two equations of defense effort separately in the preceding section.

THE DATA

The available data were a combined time-series, cross-section dataset covering all 41 Sub-Saharan African countries from 1970 to 1985.² However, some countries were excluded because they represent clearly special cases, and some other countries dropped out of the sample because of missing data on some variables.³ In the end there remained 27 countries with up to 11 years of data. Table 4.1 lists the countries and the years for which data were available.

No data source could be found that reported estimates of the fixed capital stock. For the purposes of this model, the capital stock was calculated based on all the available gross fixed capital formation data. An economic depreciation rate δ of 8 percent per year was assumed. It was also assumed that the capital stock in most African countries had been growing at a rate of approximately 5 to 6 percent per year in the sixties, the time when the available gross fixed capital formation data series started, i.e.,

$$K_t = 1.055K_{t-1}$$

Using the identity

$$K_t = (1 - \delta)K_{t-1} + I$$

one can infer that the capital stock must have been approximately 7.4 times gross fixed capital formation. This was taken as an approximate initial estimate and applied to the earliest available gross fixed capital formation estimate (usually mid-1960s). Capital stock estimates for the subsequent years were generated by continuing depreciation at 8

²For a listing and documentation of the complete database, see Murphy.

³Excluded were Lesotho and Swaziland, and dropped due to unavailability of data were Angola, Burundi, Central African Republic, Chad, Djibouti, Equatorial Guinea, Gambia, Guinea, Guinea Bissau, Mali, and Mozambique. For no country was a complete observation available after 1981.

Table 4.1
DATA COVERAGE

Country	Years										
	71	72	73	74	75	76	77	78	79	80	81
Benin	X	X	X	X	X	X	X	X	X	X	
Botswana			X	X	X	X	X	X	X	X	
Burkina Faso	X	X	X	X	X	X	X	X	X	X	
Cameroon	X	X	X	X	X	X			X		
Congo	X	X	X	X	X	X	X			X	
Ethiopia	X	X	X	X	X	X	X	X	X	X	
Gabon	X	X	X	X		X	X	X	X		
Ghana	X	X	X	X	X	X	X	X	X	X	
Ivory Coast	X	X	X	X	X	X	X	X	X	X	
Kenya	X	X	X	X	X	X	X	X	X	X	
Liberia	X	X	X	X	X	X	X	X	X	X	
Madagascar	X	X	X	X	X	X	X	X			
Malawi	X	X	X	X	X	X	X	X	X	X	
Mauritania	X	X	X	X	X	X	X	X	X	X	
Mauritius					X	X	X				
Niger	X	X	X	X	X	X	X	X	X	X	
Nigeria	X	X	X	X	X	X	X	X	X	X	
Rwanda	X	X	X	X	X	X	X	X	X	X	X
Senegal								X	X	X	
Sierra Leone	X	X	X	X	X	X	X	X	X	X	X
Sudan	X	X	X	X	X	X	X	X	X		
Tanzania	X	X	X	X	X	X	X	X			
Togo	X	X	X	X	X	X					
Uganda	X	X	X	X	X	X	X	X			
Zaire	X	X	X	X	X	X	X	X	X	X	
Zambia	X	X	X	X	X	X	X	X	X	X	
Zimbabwe	X	X	X		X	X	X	X	X	X	

Note: An "X" indicates that data for that country and year are available and included in the regressions.

percent and adding gross fixed capital formation each year. To check the sensitivity of the estimate, the calculations were performed for different assumed capital stock growth rates and depreciation rates without any significant changes in the results.

ESTIMATION PROCEDURE

The estimation procedure was 3 Stage Least Squares (3SLS) with two minor adjustments. The first was to correct for unobserved differences among countries, and the second was needed to identify the expected growth equation.

There is reason to believe that there are considerable unobserved differences between countries that persist over time. In other words, each country could have systematically higher or lower values for the dependent variables, and the explanatory variables included would not capture that difference. The standard approach for dealing with this type of problem would be to include a country-specific intercept. Unfortunately, this was not possible in the present case because variables that are constant over time are included (e.g., SOVSOC and THRT). Introducing country-specific intercepts explicitly, through dummy variables, or implicitly, by standardizing the variables and running within regressions, would lead to an underidentified model.

Ignoring this problem leads to misspecification. The expected value of the residuals for any country (i) would not be zero but a constant, say μ_i . The problem can be solved if consistent estimates of μ_i can be found.

The procedure adopted is as follows: (1) Estimate the model using 2 Stage Least Squares (2SLS). The resulting estimates of the parameters and of the residuals are consistent, albeit not efficient. (2) Obtain a consistent estimate of μ_i , say m_i , by averaging the residuals over the years within countries. (3) Subtract the m_i from the dependent variables and reestimate the model using 3SLS. The resulting estimates are consistent and efficient.

But note that, in this simultaneous system, the dependent variables also appear on the right hand side as regressors. For these regressors, the country-specific means should be added back in. This was achieved by adding the m_i as regressors and restricting their coefficients to be equal to the coefficients of the respective simultaneous variables.⁴

⁴As a check the model was also estimated without these adjustments. The changes in the coefficients were minor. Only the goodness of fit suffered somewhat and the t-ratios were generally lower.

The second adjustment concerns the specification of expected growth. Recall that the explanatory variables are intended to explain deviations from a common expected average growth rate for the entire continent. This is necessary to make identification possible. For that reason, the variables included in the expected growth equation are expressed in terms of deviations from the sample means. However, the simultaneous variables MILEX and FORCE that appear as regressors in the investment equation cannot be standardized in the same fashion. Even though the coefficient estimates for all the regressors remain unaffected, an adjustment must be made to the constant term by adding the product of the sample means and the respective coefficients for the simultaneous variables.

Identification of the relevant coefficients can now proceed as follows: (i) The adjustment coefficient λ can be calculated from the estimated coefficient on the KAPSHR term by netting out the assumed depreciation rate δ . (ii) Given an estimate of λ and an assumed average expected GDP growth rate, g^a , the coefficient α can be calculated from the (adjusted) intercept term of the INVST equation. (iii) The coefficients of the expected growth equation (γ) can then be calculated by dividing the estimated coefficients by the estimate of $\alpha\lambda$.⁵

PARAMETER ESTIMATES

The model as presented in the previous sections contains a great number of parameters. They can all be derived from the estimated coefficients of the three equation simultaneous system described above. Appendix A gives the coefficient estimates for the three equation simultaneous system, along with the relevant statistics.

The model was estimated in several variants. The results presented in this section are based on 3 stage least squares estimates (3SLS) of the fully adjusted model, i.e., adjusted for unobserved country-specific effects and using standardized variables in the expected growth equation. The military expenditure variable was based on ACDA data.

⁵For details see the discussion of the Flexible Accelerator Model in Sec. III.

Note that since the model is based on ratios of variables (e.g., MILEX = military expenditure/GDP), it was immaterial whether the data were deflated, or in which currency they were reported.

Appendix A also presents a number of alternative coefficient estimates. To test the importance of the adjustments made for country-specific effects, an unadjusted version of the model was also estimated. Finally the model was reestimated using military expenditure data published by SIPRI. As is obvious from the estimates presented in Appendix A, neither the adjustment chosen nor the source of the data qualitatively changed the results; however, the magnitude of some of the effects changed.

Effects on Expected Growth

A key variable of the model is the expected growth rate. The equation for expected growth is not estimated explicitly. Instead it is embedded in the investment equation. By assuming values for the depreciation rate ($\delta = .08$) and the average expected growth rate ($g^a = .0385$, the observed sample average), the parameters of the expected growth equation can be identified from the coefficient estimates. At the same time it is possible to identify α , the share of capital in total output, and λ , the proportion of the difference between actual and desired capital that is being filled each year. The implied parameters are given in Table 4.2.

The estimated parameters are all within reasonable limits. The parameters of the expected growth equation all have the expected signs and most are statistically significant.⁶ Only the effects of rainfall and foreign aid are not statistically significant, which is not surprising, given the contradictory effects these variables have on expected growth.

⁶Since the parameter estimates are based on nonlinear combinations of estimated coefficients, this statement should be interpreted simply as indicating that the parameters are based on coefficient estimates that are statistically significant. For the standard errors of the coefficients see Appendix A.

Table 4.2
PARAMETERS OF THE EXPECTED GROWTH EQUATION

Variable	Parameter ^a	Elasticity ^b	t-ratio ^c
MILEX	19.3855	14.4290	13.379
FORCE	-180.6437	-10.6955	-7.944
MIL	0.0847	0.5151	1.065
WAR	-0.1510	-0.0993	-0.555
GWDUMMY	-0.2629	-0.6339	-2.686
THRT	-0.4527	-2.2821	-5.162
NBORTHRT	-2.4103	-2.2411	-2.868
COOPEAST	-0.0657	-0.9151	-0.979
COOPWEST	0.1939	0.8713	3.646
GROWTH	1.4764	1.4746	4.912
EXPORTS	1.9706	14.7408	8.470
WORTH	0.5035	3.7152	5.288
AID	-0.3870	-0.1994	-0.727
RAINFALL	-0.0615	-0.0317	-0.816
MINLAG	3.1841	5.1962	8.911

Imputed Parameters:

Share of capital in output (α)	.3415
Proportion of desired investment realized each year (w)	.0511

^aImputed r s based on an assumed depreciation rate of .08 and an assumed average expected growth rate g^a of .0385 (sample average of observed growth rates).

^bElasticities evaluated at sample means.

^cAsymptotic t-ratios of the original estimated coefficients. Because the r s are ratios of random variables, the moments of their distribution do not exist. Therefore significance measures of the r s cannot be calculated.

The value of the share of capital in output (α) is certainly not unreasonable for developing countries. The estimated value of λ , the proportion of desired investment that can be undertaken within the first year (5.1 percent), may seem to be quite small. However, it is in line with estimates obtained for the U.S. economy, which range from 4 to 10 percent.⁷

⁷Clark (1979).

This implies that in the first year investors realize only about 4 to 16 percent of their desired increase in capital. Investors might want to increase investment spending faster; however, the low estimate seems to indicate that funding and other constraints prevent them from achieving this. An alternative explanation is that the costs of possible overinvestment in an uncertain environment are high. Economically speaking, the costs of adjusting to the desired higher capital stock are so high as to make only a 5 percent adjustment economically possible.⁴

Multipliers and Elasticities

By totally differentiating the system of equations and applying Cramer's rule, the multipliers for autonomous changes in any of the exogenous variables can be calculated. Of particular interest are of course the military variables MILEX and FORCE. Note that these two variables are determined jointly, i.e., an exogenous change in one of them brings about an induced change in the other. Furthermore, since the two variables have opposite effects on expected growth and investment, it is not a priori certain that increasing MILEX, for example, will lead to increases in INVSTUC. The estimated multipliers are given in Table 4.3.

Note that the multipliers given in Table 4.3 refer to the transformed variables. For example, the multiplier effect of an exogenous change in FORCE on MILEX ($d\text{MILEX}/d\text{FORCE}$) is given by $\beta_{21}/(1 - \beta_{11}\beta_{21})$ which equals 9.62. This means that an exogenous one unit increase in the *ratio of the armed forces to the total population* will result in an increase of 9.62 units in the *ratio of military expenditure to GDP*.

To obtain a measure of the effect of enlisting one more soldier on total military expenditure in dollars, some additional calculations are needed. Taking population as exogenously given, one can rewrite $d\text{MILEX}/d\text{FORCE}$ as

⁴For a discussion as to why capital adjusts so slowly to output changes, even in developed countries, see Eisner and Strotz (1963).

Table 4.3

MULTIPLIERS FOR TRANSFORMED VARIABLES

Change in Independent Variable	Change in Dependent Variable		
	dFORCE	dMILEX	dINVSTUC
dFORCE ₀	1.468882	9.620462	-1.594722
dMILEX ₀	0.071590	1.468882	0.314358
dMIL	0.000001	-0.001749	0.001025
dSOVSOC	0.002481	0.016249	-0.002693
dCOOPEAST	0.000124	0.002549	-0.000784
dCOOPWEST	-0.000283	-0.005802	0.002680
dGWDUMMY	0.000212	0.004356	-0.004385
dTHRT	0.001705	0.034976	-0.001670
dNBORTHRT	0.009774	0.200627	-0.003812

Note: Formulas for these multipliers are given in Table B.1.

$$dMILEX/dFORCE = (dMILEX/dTROOPS)POP$$

(4)

where POP refers to total population and TROOPS is the absolute size of the armed forces. The numerator and denominator of MILEX can be measured in any currency, and one can conveniently adopt dollars. We have therefore:

$$\begin{aligned} \frac{d\$MILEX/dTROOPS}{\$GDP} &= \frac{\$GDP(d\$MILEX/dTROOPS) - \$MILEX(d\$GDP/dTROOPS)}{\$GDP^2} \\ &= (1/\$GDP)\{d\$MILEX/dTROOPS - MILEX(d\$GDP/dTROOPS)\} \quad (5) \end{aligned}$$

or:

$$\begin{aligned} \frac{d\$MILEX}{dTROOPS} &= \$GDP \cdot \frac{dMILEX}{dTROOPS} + MILEX \frac{d\$GDP}{dTROOPS} \\ &= \frac{\$GDP}{POP} \cdot \frac{dMILEX}{dFORCE} + MILEX \frac{d\$GDP}{dTROOPS} \end{aligned}$$

where the prefix \$ denotes variables measured in dollars (i.e., \$MILEX is military expenditure in dollars), and d\$GDP/dTROOPS measures the effect on current \$GDP of enlisting one more soldier.

Enlisting more soldiers withdraws labor from the civilian economy, resulting in reduced output. The effect of TROOPS on \$GDP is therefore expected to be negative unless the military pay that the soldier will receive exceeds his marginal product in the civilian sector.⁹ Assuming a Cobb-Douglas production function and writing civilian labor as the difference between total labor (L) and number of armed forces (TROOPS) we can calculate d\$GDP/dTROOPS as follows:

$$\begin{aligned} \$GDP &= AK^\alpha (L - TROOPS)^{(1-\alpha)} + wTROOPS \\ d\$GDP/dTROOPS &= -(1 - \alpha) [GDP/(L - TROOPS)] + w \quad (6) \end{aligned}$$

Whether this expression is larger or smaller than zero depends on

⁹Note that the military wage bill (w.TROOPS) is also part of \$GDP.

whether the military wage (w) is larger or smaller than the marginal product in the civilian economy. Combining Eqs. (5) and (6) we can solve for the multiplier of the size of the armed forces on total military expenditure. It is given by

$$\frac{d\$MILEX}{dTROOPS} = \frac{\$GDP}{POP} \frac{dMILEX}{dFORCE} + \left[w - (1 - \alpha) \frac{\$GDP}{(L - TROOPS)} \right] \$MILEX \quad (7)$$

In the absence of any information on the military wage, w , we assume that it is roughly equal to the wage in the civilian sector of the economy which, in turn, is equal to the marginal product of labor. Under this assumption $d\$GDP/dTROOPS$ is zero and the multiplier simply becomes:

$$\frac{d\$MILEX}{dTROOPS} = \frac{\$GDP}{POP} \cdot \frac{dMILEX}{dFORCE}$$

$$= \frac{\$GDP}{POP} \cdot \frac{\beta_{21}}{(1 - \beta_{11}\beta_{21})}$$

This multiplier can be rescaled and expressed as an elasticity by multiplying it by $TROOPS/\$MILEX$. This elasticity gives the *proportional* change in defense expenditure as a result of a proportional change in the number of troops.

In an analogous fashion all the other multipliers and elasticities for autonomous changes in endogenous variables and changes in exogenous variables can be calculated. The formulas for the different multipliers are given in Appendix B, and the results based on the adjusted model are presented in Table 4.4. Table 4.5 gives elasticities for variables measured in natural units, calculated at sample means. The sample means are given in appendix Table B.3.

Table 4.4
MULTIPLIERS FOR VARIABLES MEASURED IN NATURAL UNITS

Change in Independent Variable	Change in Dependent Variable		
	dTROOPS (number)	d\$MILEX	d\$INVST
dTROOPS ₀	1.468882	\$3994.89	\$-5474.73
d\$MILEX ₀	0.000172	\$1.468882	\$2.54
dMIL	0.64	(\$ millions) -6.69	(\$ millions) 31.62
dSOVSOC	26624.84	62.16	-83.10
dCOOPEAST	1333.05	9.75	-24.20
dCOOPWEST	-3034.58	-22.19	82.69
dGWDUMMY	2278.53	16.66	-135.29
dTHRT	18294.18	133.80	-51.53
dNBORTHRT	104939.34	767.53	-179.32

Note: Formulas for these multipliers are given in Table B.2. \$MILEX and \$INVST are measured in current dollars using market exchange rates.

Note that the own multiplier of military expenditure and of size of the armed forces is larger than one (1.47). This implies that an autonomous increase in defense spending of \$1 will ultimately result in an increase in defense spending of \$1.47. The reason for this multiplier effect is that increases in defense spending bring about increases in the size of the armed forces, which in turn again puts upward pressure on defense spending, and so forth. For an autonomous increase in the size of the armed forces, exactly the same effects operate.

Countries are not ignorant of such linkages, and it is very likely that in their budgeting they take the multipliers into account and compensate for them. For example, if they consider purchasing additional equipment that costs \$1, they will budget an additional 47 cents to pay for troops to staff this new equipment and other associated expenses. Alternatively, if they wish to increase military spending by \$1 overall, they will undertake an autonomous increase of only 68 cents.¹⁰

The most obvious observation concerns the contrary effects that military spending and size of the armed forces have on gross fixed capital formation. On the one hand, the net effect of an autonomous increase in military spending, accounting for induced changes in the size of the armed forces, is quite strongly positive. An increase of \$1 leads to an increase in gross fixed capital formation of \$2.54, presumably through increases in investor confidence brought about by increased security. On the other hand, enlisting one more soldier in the armed forces has an opposite effect. It leads to a reduction in gross fixed capital formation of \$5474. This seems to indicate that large armies are not necessarily security-enhancing, but that well equipped and trained armies increase security.

The strong effect that association with the Soviet Socialist Bloc has on the three variables considered here merits mention. It leads to a large increase in the size of the armed forces (26,625 troops) and a considerable increase in defense spending (\$62 million). The net effect on gross fixed capital formation, adding in also the direct effect that association with the Soviet Socialist Bloc has on gross fixed capital formation, is strongly negative (-\$83 million). Similar, albeit smaller, effects work for countries that have simple cooperation agreements or treaties with the Eastern Bloc.

Cooperation agreements and treaties with the West have exactly the opposite effect. Countries with such agreements have smaller armed forces (-3035 troops), smaller defense expenditures (-\$22 million), and

¹⁰ $1/1.47 = .68$

larger gross fixed capital formation (+\$83 million). These effects are relative to neutral countries that have no cooperation agreements with either Bloc. They are therefore additive. A country allied to the Soviet Socialist Bloc, with an active cooperation agreement in force, will have 30,993 more troops, will spend \$94 million more for defense annually, and will have gross fixed capital formation that is \$190 million less per year than a country with an active cooperation agreement with a western country.¹¹

Table 4.5

ELASTICITIES FOR VARIABLES MEASURED IN NATURAL UNITS

With respect to:	TROOPS	Elasticity of: \$MILEX	\$INVST
TROOPS ₀	.	0.906049	-0.184760
\$MILEX ₀	0.756990	.	0.176784
MIL	0.000056	-0.012771	0.008982
SOVSOC	0.088833	0.047039	-0.009357
COOPEAST	0.008289	0.013750	-0.005078
COOPWEST	-0.058447	-0.096956	0.053746
CWDUNNY	0.007602	0.012611	-0.015233
THRT	0.127623	0.211710	-0.012132
NBORTHRT	0.135021	0.223979	-0.007787

¹¹The corresponding figures based on SIPRI estimates are 25,859 more troops, \$60 million higher defense spending, and \$221 million less fixed capital formation.

The threat variables all have the expected effects: They lead to increased troop strengths, increased military expenditure, and reduced gross fixed capital formation. Because military expenditure is so strongly associated with security threats, it is possible that military expenditure acts as a proxy in investment or growth equations that fail to separately account for threats. For example, if the investment equation did not include the threat variables, we would observe a negative coefficient on the military expenditure variable.

The large multiplier on the border threat variable may be somewhat misleading. Recall that the border threat variable is defined as the combined ratio of military expenditure to GDP in the neighboring countries to a country's own military expenditure to GDP ratio (MILEX). It is thus a rescaled measure of military expenditure in neighboring countries to GDP, and the sample mean is 3.6 percent (.036). The multiplier as defined in Table 3.4 measures the effect on the dependent variables of a one unit increase in this ratio, i.e., an increase of 100 percentage points. A more appropriate measure of the effect of increases in military expenditure in neighboring countries is given by the elasticities in the last column of Table 3.4

Finally, it is noteworthy that the type of regime (i.e., whether the country is effectively governed by the military) has no strong influence on any of the dependent variables. The multipliers are presented in Table 3.4, but they are very small and based on estimated coefficients that are not statistically significant.

The multipliers in Table 3.4 give the net effects of exogenous changes on the three endogenous variables: military expenditure, size of the armed forces, and gross fixed capital formation. Contemporaneous effects on GDP, which implicitly represent a fourth endogenous variable, can be calculated from an assumed fourth equation, e.g., the Cobb-Douglas production function. In its most basic form, the Cobb-Douglas production function has only one parameter, α , which is indirectly estimated in the investment equation and can be identified based on the two assumptions concerning average expected growth rate and economic rate of depreciation.

The effects on gross fixed capital formation have no influence on concurrent GDP. However, increased gross fixed capital formation leads to increased capital in subsequent periods, which increases potential output in future periods. The extent of this increase depends on the productivity of capital, the rate of depreciation, and the share of capital on output.

Given an assumed depreciation rate of 8 percent, a permanent increase in gross fixed capital formation of \$1 per year will ultimately lead to an increase in the capital stock of \$12.5. The multiplier of military spending on gross fixed capital formation is 2.54 (see Table 3.4), implying that a \$1 increase in defense spending leads to an increase in gross fixed capital formation of \$2.54. Accordingly, a permanent increase in defense spending of \$1 will lead, in the long run, to a fixed capital stock that is about \$32 (2.54×12.5) higher than would otherwise have been the case. Assuming a Cobb-Douglas technology with an estimate of $\alpha = .34$ (see Table 3.2), this increased defense spending will ultimately result in an increase in potential output of slightly over \$7.¹²

Such estimates of the ultimate result of increased defense spending, however, have to be interpreted with caution. The model presented here takes a Cobb-Douglas technology as given, no production function is estimated. Furthermore it is not at all certain that the capital to output ratio can be assumed to be stable. Different assumptions, and independent estimates of some of these parameters, might lead to substantially modified results. But the direction of the effects, if not the order of magnitude, should remain unchanged.

¹²Differentiating the Cobb-Douglas production function with respect to capital results in $dGDP = \alpha(GDP/K) \cdot dK$. The sample average for the output to capital ratio is about two thirds, therefore: $dGDP = .34 \$.67 \$.32 = \7.23 .

V. CONCLUSIONS

An econometric model to measure the effects of defense related variables on economic development has been constructed and estimated for a number of African countries. Contrary to much of the literature it was found that once the threats faced by the different countries were accounted for, military expenditure did not impair a country's growth chances. Instead, military expenditure was found to be associated with higher fixed capital formation, presumably through increased investor confidence in countries that are reasonably secure.

The size of the armed forces, however, has an opposite effect. Countries with large armed forces, relative to the population, were found to have lower fixed capital formation. This seems to suggest that large armies are not necessarily security-enhancing, and may indeed lead to increased insecurity. This is especially true in situations where defense expenditures per soldier are small. Troops in this type of an army tend to be ill equipped, ill trained, and usually ill paid. Armed forces of this type are often responsible for much of the insecurity in a country as they take to roadblocks and other means of extorting payments from the civilian economy.

These results suggest that the African countries could improve their security situation, and encourage more fixed capital formation, if they shifted resources within their defense budgets from troop to nontroop expenditure categories. However, experience in Africa and elsewhere has shown that it is usually very difficult to do this. Institutional constraints, fear of adding to the number of unemployed, and other political considerations, domestic and international, all make governments very reluctant to cut troop sizes. In many African countries, where the size of the army was increased in response to a national emergency or an actual war, e.g., Nigeria, Tanzania, and Angola, among others, it has taken an extremely long time to reduce the size of the armed forces to a number in line with actual security needs. More often than not the size stabilized at a level considerably above the old equilibrium.

Many African countries rely on foreign donors for a substantial portion of their nontroop expenses. As priorities of foreign donors change, so do security assistance levels. Increases in security assistance often lead the African countries to increase the size of their armed forces, and withdrawals of such assistance leave them with excess troops that are difficult to shed.

African countries may also decide to increase the size of the armed forces in anticipation of obtaining external security assistance for equipment and training. When this assistance turns out to be less than hoped for, or to be of a different kind than the country originally expected, such countries are saddled with soldiers and recruits without any resources to equip or train them. In some instances, governments may unilaterally decide to increase the size of the armed forces to pressure their patron states into increasing military assistance. For example, President Mobutu of Zaire announced suddenly in 1986 that he planned to increase the size of the armed forces by 100,000 men, knowing full well that he had no means at all to support such an army. In the eyes of most foreign advisors, there was also no need, and they all refused to materially support the scheme. Without any foreign donors willing to foot the bill for the nontroop expenses, Zaire seems, for the time being at least, to have abandoned the plan, thus avoiding a further deterioration of the situation of the Zairian armed forces.

Donors need to be conscious of the different effects that FORCE and MILEX have on security and gross fixed capital formation. Security assistance programs that aim at upgrading the existing forces, rather than increasing the force size, are clearly preferable to assistance that leads to larger armies. The U.S. program in Africa, with its heavy emphasis on training and provision of equipment, either through grants or loans, tends to aim in the right direction. Indeed most Western donors follow similar policies, and as a result, African countries associated with the West tend to have significantly smaller armies and higher fixed capital formation than neutral or Eastern Bloc allied regimes. Soviet allied regimes have larger armies and lower fixed capital formation. They also tend to have higher military expenditures

but without being able to draw security dividends from that fact, as indicated by the strong negative sign of the multipliers for SOVSOC and COOPEAST on gross fixed capital formation.

The argument that Soviet allied regimes are more threatened, and thus require larger armies, does not hold. The system was estimated explicitly accounting for the threats, internal and external, that the African countries face. Admittedly, the three variables used, guerilla activity, border with an aggressive neighbor (i.e., Libya or South Africa), and military expenditure in neighboring countries, are crude measures of "threat." However the coefficients on these variables are significant, and they do have the expected signs. The additional troops and the additional military spending of Soviet allied regimes is in addition to the amounts justified by "threats."¹

The model as presented has focused on the links between defense related variables and gross fixed capital formation. The link from capital formation to economic growth is not explicitly modeled here; however, one can presume that a higher capital stock will lead to higher potential output and thus economic growth over time.

Unlike the studies by Benoit, this positive link between defense and development does not depend on any externalities of the military, such as a "modernization perspective of the military," or "spillover effects of military R&D." It is instead the result of the military fulfilling its primary role: to provide a secure environment for economic activity. The fact that the multiplier of defense spending on gross fixed capital formation is larger than one indicates that a \$1 increase in defense spending generates more than \$1 of additional fixed capital formation and ultimately GDP, thus more than offsetting its own resource costs.

Many of Benoit's critics had found a negative relationship between defense spending and economic growth. Few of these studies, however, allow for differences in threats faced by different countries. This leads to misspecified models, where a relevant variable, threat, is

¹Also note that because of a lack of data, the two Soviet allied regimes that could be considered most threatened from abroad, Angola and Mozambique, are not included in the estimation.

excluded from the growth equation. Since threats and defense spending are closely and positively associated with each other, defense spending tends to act as a proxy for threats in such models, which explains the negative coefficients estimated.

Cooperation agreements and treaties usually involve much more than only security arrangements. For this reason, COOPEAST and COOPWEST were included in the gross fixed capital formation equation as well. COOPWEST was found to have a positive effect, while COOPEAST had a negative effect. Furthermore, these direct effects on gross fixed capital formation were found to be strong enough to offset the indirect effects these variables had through the MILEX equation.² The same holds true for the variable WAR, which was found to have a negative, albeit statistically insignificant, direct effect on gross fixed capital formation.

Wherever assumptions had to be made in the model, the most conservative were chosen. For example, the model fails to account for the positive externalities of the military through human capital formation and civic action.³ The main results presented are based on ACDA data; estimates based on SIPRI data would have resulted in a defense spending multiplier almost twice as large.⁴ Finally, the negative effects of drawing manpower from the civilian sector into the armed forces are incorporated into the calculated multipliers; however, the positive spillover effects of spending by the military on domestically produced goods (e.g., food) are not. It is therefore fair to conclude that our results understate the positive effects of defense spending on economic growth.

²Recall that COOPWEST had a negative effect on MILEX and COOPEAST had a positive one. If COOPEAST and COOPWEST were not included in the investment equation, one would have to conclude that they have (indirectly) the same effects on gross fixed capital formation. However, the direct effects that these variables have on investment offset their indirect effects.

³Civic action is the topic of another publication from the same project: Elliot Berg et al.

⁴See the coefficient estimates based on SIPRI data in Appendix A.

Appendix A

COEFFICIENT ESTIMATES

Recall the three equation simultaneous system of equations presented in Sec. IV:

$$\begin{aligned} \text{FORCE} = & \beta_{10} + \beta_{11} \text{MILEX} + \beta_{12} \text{MIL} + \beta_{13} \text{SCHOOL} \\ & + \beta_{14} \text{SOVSOC} \end{aligned} \quad (1)$$

$$\begin{aligned} \text{MILEX} = & \beta_{20} + \beta_{21} \text{FORCE} + \beta_{22} \text{MIL} + \beta_{23} \text{WAR} \\ & + \beta_{24} \text{GWDUMMY} + \beta_{25} \text{THRT} + \beta_{26} \text{BORTHRT}_{2-1} \\ & + \beta_{27} \text{COOPEAST} + \beta_{28} \text{COOPWEST} \end{aligned} \quad (2)$$

$$\begin{aligned} \text{INVSTUC} = & \beta_{30} + \beta_{31} \text{MILEX} + \beta_{32} \text{FORCE} + \beta_{33} \text{MIL} \\ & + \beta_{34} \text{WAR} + \beta_{35} \text{GWDUMMY} + \beta_{36} \text{THRT} \\ & + \beta_{37} \text{BORTHRT} + \beta_{38} \text{COOPEAST} + \beta_{39} \text{COOPWEST} \\ & + \beta_{310} \text{GROWTH} + \beta_{311} \text{EXPORTS} + \beta_{312} \text{WORTH} \\ & + \beta_{313} \text{AID} + \beta_{314} \text{RAINFALL} + \beta_{315} \text{MINLAG} \\ & + \beta_{316} \text{KAPSHRUC} \end{aligned} \quad (3)$$

where the variables are defined as follows:

- FORCE = ratio of armed forces to total population
- MILEX = ratio of military expenditures to GDP
- INVSTUC = ratio of gross fixed capital formation to GDP, multiplied by user cost of capital
- MIL = dummy variable equal to one if country is effectively governed by the military
- SCHOOL = proportion of total population enrolled in secondary education
- SOVSOC = dummy variable for Soviet Socialist regimes (see Table 2.1)
- WAR = dummy variable equal to one if country is engaged in a war
- GWDUMMY = dummy variable equal to one if there is significant guerilla activity

- THRT = dummy variable equal to one if country borders on Lybia or South Africa
- BORTHRT = weighted sum of neighboring countries' military expenditure to own military expenditure, lagged by one period. (Summation weights: proportion of shared border; currency conversion at purchasing power parities. See Murphy for details.)
- COOPEAST = dummy variable equal to one if the country has an active friendship accord or treaty with the Soviet Bloc
- COOPWEST = dummy variable equal to one if the country has an active friendship accord or treaty with a Western power
- GROWTH = GDP growth rate, lagged by one period
- EXPORTS = ratio of exports to GDP
- WORTH = proportion of nonconcessionary bank financing in total borrowing
- AID = ratio of official development assistance to GDP
- RAINFALL = annual rainfall (deviation from 20-year average)
- MINLAG = proportion of GDP generated in the mining sector, lagged by one period
- KAPSHRUC = ratio of fixed capital stock to GDP, multiplied by user cost of capital

This system was estimated in several variants. Model I was estimated by the modified 3SLS method described in the text and uses estimates of military expenditure in local currency compiled by ACDA.¹ Model II is based on the same data, but the estimates were not adjusted for the unobserved country specific effects. Model III uses the same estimation method as model I, but the estimates of military expenditure were taken from SIPRI. Finally, model IV uses ACDA estimates in constant 1982 dollars. Instead of the ratio of military expenditure to GDP, these

¹Actually the data were obtained from Professor Robert West, Fletcher School of Law and Diplomacy of Tufts University. West's data were available in machine readable form and provided somewhat better coverage.

last estimates are based on GNP in the denominator, because no GDP estimates deflated according to the ACDA method were available.

Table A.1
COEFFICIENT ESTIMATES FOR DIFFERENT VARIANTS
OF THE ESTIMATION MODEL

Coefficient Estimates (t-ratios in parentheses)				
	Model I	Model II	Model III	Model IV
FORCE Equation:				
Intercept	0.000318 (2.36)	-0.000022 (0.09)	0.000145 (0.94)	0.000370 (2.80)
MILEX	0.048738 (24.27)	0.051283 (11.27)	0.050441 (19.44)	0.045558 (24.62)
MIL	0.000086 (0.51)	0.000585 (2.07)	-0.000115 (0.68)	0.000106 (0.64)
SCHOOL	0.003032 (3.95)	0.004812 (3.53)	0.005012 (5.85)	0.002815 (3.71)
SOVSOC	0.001689 (9.60)	0.000851 (2.71)	0.001628 (8.35)	0.001743 (10.03)
MILEX Equation:				
Intercept	0.004624 (1.94)	0.004424 (0.98)	0.010407 (4.15)	0.004008 (1.59)
FORCE	6.549513 (11.55)	8.756565 (6.64)	3.890529 (6.31)	7.221210 (12.07)
MIL	-0.001753 (0.75)	-0.006741 (1.85)	0.001654 (0.74)	-0.002478 (1.00)
WAR	0.060967 (10.24)	0.058017 (5.22)	0.067952 (10.51)	0.064808 (10.30)
GWOLMY	0.002966 (1.11)	0.004771 (1.13)	0.014101 (4.75)	0.002457 (0.88)
THRT	0.023811 (10.72)	0.014029 (3.97)	0.011342 (4.72)	0.025560 (10.90)
BORTHRT	0.136585 (5.90)	0.045842 (1.19)	0.101986 (4.05)	0.148333 (6.06)
COOPEAST	0.001735 (0.90)	0.006972 (2.23)	0.002646 (1.24)	0.000846 (0.42)
COOPWEST	-0.003950 (2.68)	-0.003044 (1.32)	-0.003481 (2.15)	-0.004233 (2.72)
INVSTUC Equation:				
Intercept	0.018097 (14.63)	0.013504 (2.73)	0.011921 (6.42)	0.018537 (13.44)
MILEX	0.392082 (13.38)	0.961888 (4.09)	0.688610 (12.64)	0.338344 (12.42)
FORCE	-3.653617 (7.94)	-8.335592 (4.56)	-4.705059 (8.01)	-3.356418 (7.44)
MIL	0.001713 (1.06)	0.006301 (2.09)	-0.000214 (0.11)	0.001785 (1.13)
WAR	-0.003053 (0.55)	-0.036834 (1.94)	-0.020473 (3.07)	-0.002066 (0.38)
GWOLMY	-0.005317 (2.69)	-0.007281 (1.97)	-0.012805 (4.69)	-0.005055 (2.59)
THRT	-0.009155 (5.16)	-0.018308 (2.76)	-0.007487 (3.77)	-0.008496 (4.83)
BORTHRT	-0.048749 (2.87)	-0.088157 (2.01)	-0.061547 (3.04)	-0.046082 (2.74)
COOPEAST	-0.001330 (0.98)	-0.006714 (1.99)	-0.001856 (1.09)	-0.001077 (0.81)
COOPWEST	0.003922 (3.65)	0.006547 (3.20)	0.004637 (3.57)	0.003876 (3.64)
GROWTH	0.029861 (4.91)	0.072455 (4.82)	0.031413 (4.92)	0.029725 (4.91)
EXPORTS	0.039857 (8.47)	0.038983 (4.71)	0.040390 (8.13)	0.038302 (8.19)
WORTH	0.010183 (5.29)	0.009660 (2.43)	0.008730 (4.20)	0.010261 (5.35)
AID	-0.007826 (0.73)	-0.007810 (0.39)	-0.019100 (1.61)	-0.007208 (0.67)
RAINFALL	-0.031245 (0.82)	-0.002940 (1.20)	-0.001068 (0.67)	-0.001198 (0.79)
MINLAG	0.064400 (8.91)	0.064830 (5.05)	0.069298 (9.10)	0.063895 (8.88)
KAPSHRUC	0.028930 (7.24)	0.023042 (3.38)	0.035143 (8.39)	0.028927 (7.27)
System				
mean squared error:	2.0602	1.7757	1.7544	2.0870
R-squared:	0.7554	0.5832	0.7206	0.7592

Appendix B

DERIVING MULTIPLIERS AND ELASTICITIES

The multipliers for the transformed variables FORCE, MILEX, and INVSTUC can be derived simply by applying Cramer's rule to the coefficient estimates. The resulting multipliers, given in Table 4.3 in the text, give the effect of an autonomous change in any of the independent variables on the dependent variables. Table B.1 gives the formulas on which the multipliers in Table 4.3 are based.

Table B.1

MULTIPLIER FORMULAS FOR TRANSFORMED VARIABLES

Change in Independent Variable	Change in Dependent Variable		
	dFORCE	dMILEX	dINVSTUC
dFORCE _o ^a	1/D ^b	β_{21}/D	$(\beta_{31}\beta_{21}+\beta_{32})/D$
dMILEX _o	β_{11}/D	1/D	$(\beta_{31}+\beta_{32}\beta_{11})/D$
dSOVSOC	β_{14}/D	$\beta_{21}\beta_{14}/D$	$(\beta_{14}(\beta_{31}\beta_{21}+\beta_{32}))/D$
dGWDUMMY	$\beta_{11}\beta_{24}/D$	β_{24}/D	$\beta_{24}(\beta_{31}+\beta_{32}\beta_{11})/D + \beta_{35}$
dTHRT	$\beta_{11}\beta_{25}/D$	β_{25}/D	$\beta_{25}(\beta_{31}+\beta_{32}\beta_{11})/D + \beta_{36}$
dBORTHRT	$\beta_{11}\beta_{26}/D$	β_{26}/D	$\beta_{26}(\beta_{31}+\beta_{32}\beta_{11})/D + \beta_{37}$
dCOOPEAST	$\beta_{11}\beta_{27}/D$	β_{27}/D	$\beta_{27}(\beta_{31}+\beta_{32}\beta_{11})/D + \beta_{38}$
dCOOPWEST	$\beta_{11}\beta_{28}/D$	β_{28}/D	$\beta_{28}(\beta_{31}+\beta_{32}\beta_{11})/D + \beta_{39}$
dMIL	$(\beta_{11}\beta_{22}+\beta_{12})/D$	$(\beta_{22}+\beta_{12}\beta_{21})/D$	$(\beta_{22}+\beta_{12}\beta_{21})(\beta_{31}+\beta_{32}\beta_{11})/D + \beta_{33}$

^aThe subscript o denotes autonomous changes in endogenous variables.

^bD = $(1 - \beta_{11}\beta_{12})$, i.e., the determinant of the simultaneous subsystem consisting of the FORCE and MILEX equations.

The multipliers based on the formulas in Table B.1 are not always easy to interpret. For example $dMILEX/dSOVSOC$ is the increase in military expenditure *as a proportion of GDP* that is due to affiliation with the Soviet Bloc. But what portion of this change is due to a change in the numerator, and what portion is due to a change in the denominator, is unclear. The interpretation of these multipliers is therefore not as straightforward as one might wish.

Part of the problem is that there is a fourth endogenous variable, GDP, which is part of the system.¹ No separate equation for GDP is estimated, however. GDP is assumed to be produced by a Cobb-Douglas production function, and the single parameter of this production function (α) is indirectly estimated in the INVSTUC equation. But this relationship can be used to calculate the effects of the independent variables on the untransformed variables such as military spending and gross fixed capital formation measured in dollars, and troop strength measured in number of soldiers.

Let the prefix \$ denote variables measured in (current) dollars and let the number of soldiers in the armed forces be denoted by the variable TROOP. The multipliers for the untransformed variables, \$MILEX, \$INVST, and TROOPS, can be derived for any of the exogenous changes of interest. The method essentially involves differentiating the transformed variables and taking into account that the denominator of the ratio may be affected by the exogenous change as well.

It is assumed that changes in military expenditure have no influence on current GDP. Changing military expenditure involves essentially a reallocation of current production, which should not affect GDP directly.² This argument would be sufficient if one was dealing simply with a time series of observations for one country. But since the data consist of a pooled set of time series/cross section observations, this may no longer be strictly true. It is likely that a

¹Population is assumed to be exogenous.

²Production in the future, however, will be affected, since defense spending influences investment and thus future potential output.

country with high military expenditure in period t also had high military expenditure in period $t - 1$. Accordingly, military expenditure could have a direct effect on GDP. The formulas given in this appendix allow for that possibility by including the parameter ϵ , which denotes the elasticity of GDP with respect to concurrent military expenditure. To benchmark the estimates, the value of this parameter is assumed to be zero, but alternative estimates for different assumptions can readily be calculated.

Changes in military manpower, however, influence current GDP directly. Increasing the size of the armed forces draws manpower from the civilian sector of the economy, which reduces labor available for production. The effect of this on GDP is clearly negative and is given in Eq. (6) in the text.

A final correction concerns INVSTUC. Recall that this variable is defined as the ratio of gross fixed capital formation to GDP multiplied by the user cost of capital. The user cost of capital is a function of depreciation and the interest rate. Depreciation is essentially technologically determined and for most African countries the effective interest rate is the world market rate. Neither is likely to be influenced by any of the variables included in the system considered here. Assuming the user cost of capital to be exogenously determined is probably not unreasonable and allows a very straightforward adjustment to the estimated multipliers.

The power of this assumption should not be underestimated, however. Even though military expenditure is only about two and one half percent of GDP in the countries considered here, it is nevertheless possible that increases in military expenditure put upward pressure on interest rates, thus leading to increased user costs of capital. This would tend to crowd out investment; however, in the model considered here, this crowding out could not be detected, since the dependent variable in the third equation is the product of gross fixed capital formation and user costs. A drop in gross fixed capital formation could theoretically at least be masked by an increase in user costs.

However, note that the observed variable was gross fixed capital formation, and that the dependent variable for the regressions was obtained by multiplying this variable with an assumed (and fixed) value of user costs of capital. The estimated coefficients therefore cannot possibly reflect variations in user costs rather than gross fixed capital formation, simply because there is no variation among countries in user costs. There is only a slight variation over time in line with the general increase in interest rates during the observation period.

The model presented here is unable to identify any crowding out of gross fixed capital formation, either private or public, by MILEX.³ This does not imply that the resulting coefficient estimates are somehow biased. Note that the observed value of gross fixed capital formation is "net," i.e., after crowding out has already occurred. If there is any crowding out taking place, the estimated coefficient of MILEX in the INVSTUC equation already reflects it. It is in fact the sum of the (positive) effect that MILEX has on gross fixed capital formation through the security relationship, and the (negative) effect it might have on gross fixed capital formation through the user costs of capital (crowding out).

Table B.2 gives the adjusted multipliers for the variables in natural units (e.g., $d\text{INVST}/d\$MILEX$ or $d\$MILEX/d\text{TROOPS}$). The values for these adjusted multipliers are given in Table 4.4 in the text. In many instances, elasticities give a more accurate impression of the effects of autonomous changes on the endogenous variables. Elasticities give the proportional reaction in the dependent variable resulting from a proportional change in the independent variable. To obtain elasticities, multipliers have to be rescaled, i.e., the elasticity of $\$MILEX$ with respect to TROOPS is given by $(d\$MILEX/d\text{TROOPS})(\text{TROOPS}/\$MILEX)$. By convention, the rescaling is done at sample means. The sample means for the different variables are given in Table B.3.

³See Gyimah-Brempong for an analysis of tradeoffs between military expenditure and other components of the public budget. He finds no crowding out of other budget categories by MILEX.

Table B.2

MULTIPLIER FORMULAS FOR VARIABLES IN NATURAL UNITS

Change in Independent Variable	Change in Dependent Variable			
	dTROOPS	d\$MILEX	d\$INVST	
dTROOPS ₀	$\frac{1}{D}$	$\frac{\beta_{21}\$GDP}{D \cdot POP}$	$\frac{(\beta_{31}\beta_{21}+\beta_{32})\$GDP}{D \cdot POP \cdot UC}$	$\frac{(1 - \alpha)\$INVST}{(L - TROOPS)}$
d\$MILEX ₀	$\frac{\beta_{11}(1 - \epsilon)}{D(\$GDP/POP)}$	$\frac{1}{D}$	$\frac{\beta_{31}+\beta_{32}\beta_{11}}{D}(1-\epsilon) + \frac{\$INVST}{\$MILEX} \epsilon$	
dSOVSOC	$\frac{\beta_{14}POP}{D}$	$\frac{\beta_{21}\beta_{14}\$GDP}{D \cdot POP}$	$\left[\frac{\beta_{14}(\beta_{31}\beta_{21}+\beta_{32})}{D} \right] A^*$	
dGWDUMMY	$\frac{\beta_{11}\beta_{24}POP}{D}$	$\frac{\beta_{24}\$GDP}{D(1-\epsilon)}$	$\left[\frac{\beta_{24}(\beta_{31}+\beta_{32}\beta_{11})}{D} + \beta_{35} \right] A^*$	
dTHRT	$\frac{\beta_{11}\beta_{25}POP}{D}$	$\frac{\beta_{25}\$GDP}{D(1-\epsilon)}$	$\left[\frac{\beta_{25}(\beta_{31}+\beta_{32}\beta_{11})}{D} + \beta_{36} \right] A^*$	
dBORTHRT	$\frac{\beta_{11}\beta_{26}POP}{D}$	$\frac{\beta_{26}\$GDP}{D(1-\epsilon)}$	$\left[\frac{\beta_{26}(\beta_{31}+\beta_{32}\beta_{11})}{D} + \beta_{37} \right] A^*$	
dCOOPEAST	$\frac{\beta_{11}\beta_{27}POP}{D}$	$\frac{\beta_{27}\$GDP}{D(1-\epsilon)}$	$\left[\frac{\beta_{27}(\beta_{31}+\beta_{32}\beta_{11})}{D} + \beta_{38} \right] A^*$	
dCOOPWEST	$\frac{\beta_{11}\beta_{28}POP}{D}$	$\frac{\beta_{28}\$GDP}{D(1-\epsilon)}$	$\left[\frac{\beta_{28}(\beta_{31}+\beta_{32}\beta_{11})}{D} + \beta_{39} \right] A^*$	
dMIL	$\frac{(\beta_{11}\beta_{22}+\beta_{12})POP}{D}$	$\frac{(\beta_{22}+\beta_{12}\beta_{21})\$GDP}{D(1-\epsilon)}$	$\frac{(\beta_{22}+\beta_{12}\beta_{21})(\beta_{31}+\beta_{32}\beta_{11})}{D} + \beta_{33} A^*$	

*A $\equiv (\$GDP/UC)(1 + \epsilon_{UC,I} - \epsilon_{\$GDP,I})$, where $\epsilon_{UC,I}$ is the elasticity of user cost with respect to investment, and $\epsilon_{\$GDP,I}$ is the elasticity of (current) \$GDP with respect to investment. For the evaluation of the elasticities in Table 3.4 the difference between them is assumed to be close to zero.

Table B.3

SAMPLE MEANS FOR VARIABLES USED IN THE MODEL

Variable	Means	Std. Dev.
FORCE	0.00227949	0.00171929
MILEX	0.02865629	0.02512733
INVSTUC	0.02622628	0.01703044
USERCOST	0.12400000	0.03000000
GROWTH	0.03845231	0.07720065
BORTHRT	0.03579727	0.03629539
SCHOOL	0.12807659	0.06471271
MIL	0.23417722	0.37253805
GWDUMMY	0.09282700	0.29080401
THRT	0.19409283	0.39633774
SOVSOC	0.09282700	0.29080401
RAINFALL	0.01983620	0.29165858
AID	0.06663084	0.06317046
WAR	0.02531646	0.15741693
EXPORTS	0.28798962	0.13976522
MINLAG	0.06282950	0.09345164
KAPSHRUC	0.18051811	0.13933229
WORTH	0.28409684	0.28002751
COOPEAST	0.17299578	0.37904414
COOPWEST	0.53586498	0.49976752
\$GDPLC (mil. local currency)	138465.02	300096.30
\$GDPLC/CAP (local currency)	46301.47	143784.13
\$GDPDOL (mil. dollars)	3825.68	9181.92
\$GDPDOL/CAP (dollars)	416.98	602.70
\$GFXCAPFORMLC (mil. local currency)	33806.59	86152.01
\$GFXCAPFORMLC/CAP (local currency)	17433.39	75796.17
\$GFXCAPFORM (mil. dollars)	824.41	2454.02
\$GFXCAPFORMDOL/CAP (dollars)	118.46	324.67
\$MILEXLC (mil. local currency)	2357.45	4129.20
\$MILEXLC/CAP (local currency)	848.86	2538.49
\$MILEXDOL (mil. dollars)	122.67	316.34
\$MILEXDOL/CAP	11.58	18.04
TROOPS (thousands)	27.82	59.89
POPULATION (millions)	10.73	15.57
LABORFORCE (millions)	4.47133	6.18483
LABORFORCE/CAP	0.40716	0.06970

BIBLIOGRAPHY

- Ball, Nicola, "Defense and Development: A Critique of the Benoit Study," *Economic Development and Cultural Change*, Vol. 31, April 1983, pp. 507-524.
- Ball, Nicola, *Third World Security Expenditure: A Statistical Compendium*, FAO Report C 10250-M5, May 1984.
- Banks, Arthur S., *Cross-National Time-Series Data Archive User's Manual*, rev. ed., Center for Social Analysis, State University of New York at Binghamton, September 1979.
- Baynham, S. J., "The Military in Ghanaian Politics," *Army Quarterly and Defence Journal*, Vol. 106, October 1976, pp. 428-439.
- Benoit, Emile, "Economic Contents of Defense Programs and Opportunity Costs," *Defense and Economic Growth in Developing Countries*, Heath, Lexington, Mass., 1973.
- Benoit, Emile, "Growth and Defense in Developing Countries," *Economic Development and Cultural Change*, Vol. 26, January 1978, pp. 271-280.
- Berg, Elliot and Alexander Berg, *Security Expenditures in Senegal: An Analysis of National Data*, N-2655-USDP.
- Berg, Elliot, with the assistance of Jeremy Foltz, *The Nonmilitary Uses of Military Forces*, The RAND Corporation, N-2656-USDP.
- Clark, Peter K., "Investment in the 1970s: Theory, Performance, and Prediction," *Brookings Papers on Economic Activity*, Vol. 1, 1979.
- Eisner, Robert, and Robert H. Strotz, "Determinants of Business Investment," in Daniel Suits et al., *Impacts of Monetary Policy, a Series of Research Studies for the Commission on Money and Credit*, Prentice-Hall, Englewood Cliffs, N.J., 1963, pp.59-338.
- Fernandez, Judith C., *Some Evidence on the Relation Between Military Rule and Economic Regime in Sub-Saharan Africa*, The RAND Corporation, N-2652-USDP.
- Gyimah-Brempong, Kwabena, *Defense and Development in Africa: A Review of the Statistical and Econometric Literature*, The RAND Corporation, N-2650-USDP.
- International Institute for Strategic Studies (IISS), *The Military Balance*, London, various years.

Murphy, Patrick J., *Defense and Development in Sub-Saharan Africa: The Database and Codebook*, The RAND Corporation, N-2651-USDP.

Rosberg, James, Kwabena Gyimah-Brempong, and Francois Goreux, *Defense and Development in Africa: Annotated Bibliography*, N-2657, USDP, October 1987.

U.S. Arms Control and Disarmament Agency (ACDA), *World Military Expenditure and Arms Transfers*, Washington, D.C., various years.

West, Robert L., "Improved Measures of Defense Burden in Developing Countries," paper presented at Defense, Security and Development Colloquium at Birkbeck College, London, March 1986.